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*Examiner: Kang, Hye-Shung*

(54) LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF MANUFACTURING SAME

**[Abstract]**

The present invention relates to a liquid crystal display device and a method of manufacturing the same. According to the present invention, a black matrix is formed in a one unit such that the matrix is superposed on one side of a thin film transistor region, a gate line, a data line, and a pixel electrode, and a capacitor formed with the pixel electrode and the black matrix is used as a storage capacitor by using the black matrix as a common electrode, thereby reducing the area occupied by the storage capacitor in a pixel region. Therefore, the liquid crystal display device with high aperture can be manufactured by the present invention.

**[Specification]**
**[Brief Description of the Drawings]**

Fig. 1 is a general circuit diagram of a liquid crystal display device.

Fig. 2 is a layout diagram of a liquid crystal display device according to the conventional technology.

Figs. 3A-3H are cross sectional views to describe steps of manufacturing the liquid crystal display device across the I-I line shown in Fig. 2.

Fig. 4 is a layout diagram of a liquid crystal display device according to the first embodiment of the present invention.

Figs. 5A-5G are cross sectional views along the II-II line of Fig. 4 showing a manufacturing process of the liquid crystal display device.

Fig. 6 is a layout diagram of a liquid crystal display device according to the second embodiment of the present invention.

Figs. 7A-7H are cross sectional views along the III-III line in Fig. 6 showing a manufacturing process of the liquid crystal display device.

* Description for Numerals in the Drawings

| | |
|---|---|
| 41, 61: transparent insulating substrate | 42, 62: active layer |
| 43, 63: gate insulating film | 44, 64: gate electrode |
| 45, 65: the first interlayer insulating film | 46, 66: the first contact hole |
| 47, 67: data line | 48, 68: the second interlayer insulating film |
| 49, 71: the second contact hole | 50, 72: pixel electrode |
| 51, 70: insulating film | 52, 69: black matrix |
| 53, 73: protecting film | |

The invention relates to a liquid crystal display device. More specifically, the invention relates to a liquid crystal display device for improving the aperture rate and the method of manufacturing the same.

Generally, the liquid crystal display device comprises of a lower substrate, in which a thin film transistor (TFT) and pixel electrodes are arranged, an upper substrate, in which a color filter, a common electrode and a black matrix layer are formed, and liquid crystals, which filled a space between the two substrates.

Referring to figure 1 showing a circuit composition of such a liquid crystal display device, a plurality of Gate Lines, G/L1, G/L2, G/L3... are arranged in one direction with predetermined intervals. A plurality of Data Lines, D/L1, D/L2, D/L3... are arranged in vertical direction to the Gate Lines with predetermined intervals. Thin film transistors $Q_{11}$, $Q_{12}$, $Q_{21}$, $Q_{22}$ ... are formed between each Gate Line and Data Line in a matrix, and operate as a switch to apply the signal of the Data Lines to the pixel electrodes in response to the signal of the Gate Lines. A laminated storage capacitor Cst and a liquid crystal capacitor $C_{LC}$ with liquid crystal layer as a dielectric are formed at the pixel electrode.

Here, when a signal voltage is applied to the Gate Line, the thin film transistor is turned on. In the meantime, the data voltage including information related to an image is applied to the Data Line. Then, the voltage applied to the Data Line is passed through the thin film transistor to charge the liquid crystal capacitor $C_{LC}$, thereby operating the liquid crystal display device.

The conventional liquid crystal display device comprising such circuit composition is described with reference to the attached figures as follows.

Figure 2 shows a layout of the conventional liquid crystal display device. Figure 3a – 3h show the process for making the liquid crystal display device in accordance with I-I line of Figure 2.

As seen in Figure 3a, polycrystalline silicon is deposited on a transparent insulating substrate 1 such as glass, crystal, etc. and patterned to form an active layer 2 in an island form.

Then, as seen in Figure 3b, after depositing and patterning the photo resist film 3, ionized impurities P or B are injected into the active layer 2 using the photoresist film 3 as a mask to define a lower electrode region of the storage capacitor.

Then, as seen in Figure 3c, the photo resist film 3 is removed. Gate insulating film 4 is formed on the fore surface of the substrate 1 including the active layer 2. Gate electrode material is deposited on the Gate insulating film 4 and patterned to form the Gate electrode 5 and an upper electrode 5' of the storage capacitor. The Gate electrode 5 is used as a Gate Line and the upper electrode 5' of the storage capacitor is used as the common electrode line.

Then, the ionized impurities P or B are injected to the active layer 2 using the Gate electrode 5 as a mask. The injected ionized impurities are activated by heating process to form a source region and a drain region of the thin film transistor.

Then, as seen in Figure 3d, a first interlayer dielectric film 6 is deposited on the fore surface of the substrate 1 including the Gate electrode 5. The first interlayer insulating film 6 and the Gate insulating film 4 are selectively removed to expose the source region of the active layer 2, thereby to form a metal contact hole 7.

Then, as seen in Figure 3e, a metal electrode 8 is formed, which is connected to the source region of the active layer 2 via the metal contact hole 7. The metal electrode 8 is used as the Data Line

Then, a second interlayer insulating film 9 is deposited on the fore surface of the substrate 1 including the metal electrode 8.

Then, as seen in Figure 3f, the gate insulating film 4 and the first and second interlayer insulating film 6, 9 are selectively removed to expose the drain region of the active layer 2, thereby to form a pixel electrode contact hole 10.

Then, as seen in Figure 3g, a transparent electric material is deposited on the second interlayer insulating film 9 and patterned to form a pixel electrode 11, which is connected to the active layer 2 via the pixel electrode contact hole 10.

Then, as seen in Figure 3h, an insulating film 12 such as silicon nitride is deposited on the fore surface of the substrate 1 including the pixel electrode 11. Then, a black matrix 13 is deposited and patterned in order to avoid light leakage around the boundaries between the thin film transistor and the pixel electrode. Then, a protective film 14 is deposited on the fore surface of the substrate 1 including the black matrix 13. Then the pad is opened to complete the fabrication of the lower substrate of the liquid crystal display device.

**[Summary of the Invention]**

In the conventional liquid crystal display, a storage capacitor is comprised of an active layer – a gate insulating film – a gate electrode. Thus, the storage capacitor is opaque and

occupies a wide area. Therefore, there is a problem that an aperture ratio is low. Further, during a process of patterning a photo-resistive film on the active layer and implanting an impurity for making a lower electrode of the storage capacitor, the active layer may be contaminated. Also, when removing the photo-resistive film, a surface of the active layer may be damaged, deteriorating the performance of resulting device.

To solve the above-mentioned problems, the present invention provides a liquid crystal display in which a size of a storage capacitor is reduced and an aperture ratio is improved, and a method for manufacturing the same.

**[Detailed Description of the Invention]**

In a liquid crystal display and a method of manufacturing the same, according to the present invention, a black matrix is formed in a single unit to overlap with thin film transistor regions, gate and data lines, and a side of each pixel region and is used as a common electrode, wherein a capacitor comprised of the black matrix and the pixel electrode is used as the storage capacitor. Thus, the area in the pixel region occupied by the storage capacitor can be reduced and the aperture ratio of the liquid crystal display can be improved.

Hereafter, with reference to accompanying drawings, a liquid crystal display according to the present invention is described in detail together with a method of manufacturing the same.

Fig. 4 is a layout view showing a liquid crystal display according to the first embodiment of the present invention. Figs. 5a – 5g are cross-sectional views along II - II line of Fig. 4 showing a manufacturing process of the liquid crystal display. Fig. 6 is a layout view showing a liquid crystal display according to the second embodiment of the present invention. Figs. 7a – 7g are cross-sectional views along III - III line of Fig. 6 showing a manufacturing process of the liquid crystal display.

According to Fig. 4, a structure of the liquid crystal display has a plurality of gate lines 44 spaced from each other by a fixed distance and, in perpendicular direction to the gate lines 44, a plurality of data lines 47 spaced from each other by a fixed distance. Also, an active layer 42 of an island shape including a source region and a drain region is formed in each pixel region on a substrate on which the gate lines 44 and the data lines 47 are formed. Here, a thin film transistor is formed by defining the active layer 42 as an active region, the gate line 44 as the gate electrode, and the data line as the source electrode.

Moreover, a pixel electrode 50 is formed in each pixel region and connected to the drain region of the active layer 42. At upper side of the pixel electrodes 50, a black matrix is formed in a single unit to overlap with the thin film transistor regions, the gate and data lines 44, 47, and a side of each pixel region. Also, the black matrix 32 is used as a common electrode. Here, a capacitor comprised of the pixel electrode 50 – insulating film (not shown) – the black matrix 52 is used as a storage capacitor.

A method of manufacturing the liquid crystal display having such a structure according to the first embodiment is described below.

Referring to Fig. 5a, firstly, poly-crystalline silicon is deposited on the thin film

transistor area of a transparent insulating substrate 41 such as glass or quartz and patterned to form the active layer 42 of the island shape.

Referring to Fig. 5b, a gate insulating film 43 is formed over the fore surface the active layer 42 and then the gate electrode 44 is formed by depositing and patterning a gate electrode material over the fore surface of the substrate 41 including the gate insulating film 43. Subsequently, an impurity is ion-implanted into the active layer 42 using the gate electrode 44 as a mask, and the source and the drain regions are formed by activating the implanted impurity through a thermal process.

Also, referring to Fig. 5c, a first inter-layer insulating film 45 is deposited over the fore surface of the substrate 41 including the gate electrode 44, and then the first contact hole 46 is formed by removing a portion of the gate insulating layer 43 and the first inter-layer insulating layer on the source region of the active layer 42.

Subsequently, referring to Fig. 5d, a metal is deposited over the fore surface of the substrate 41 including the first inter-layer insulating film 45 and patterned to form the data line 47 connected to the active layer 42 through the first contact hole 46.

Further, referring to Fig. 5e, the second inter-layer is deposited over the fore surface of the substrate 41 including the data line 47. Subsequently, the gate insulating layer 43 and the first and the second inter-layer insulating films 45, 48 are selectively removed to form the second contact hole 49 through which the drain region of the active layer 42 is exposed.

Continuously, as illustrated in Fig. 5f, transparent conducting material such as ITO (Indium Tin Oxide) is deposited and patterned on the second interlayer insulating film 48 to form a pixel electrode 50 as to be connected with the active layer 42 via the second contact ole 49.

Then, as illustrated in Fig. 5g, an insulating film 51 such as Silicon Nitride is deposited on the fore surface of a substrate 41 including a pixel electrode 50. After that, a black matrix 52 is deposited and patterned in an integrated form that is superposed on one side of the pixel electrode 50, a data line 47, a gate line 44 and a thin film transistor region, and connected to the common electrode. Here, the pixel electrode 50, the insulating film 51 and the black matrix 52 are superposed and form a storage capacitor. Also, the black matrix 52 is used as an upper electrode of the storage capacitor.

Continuously, manufacturing lower substrate of a LCD is completed by depositing a protective film 53 on the fore surface of the substrate 41 including the black matrix 52, and opening a PAD.

The second embodiment of the invention as another embodiment of such a LCD will be described below.

As illustrated in Fig. 6, a LCD according to the invention has a structure forming a plurality of gate lines 64 at regular intervals, and a plurality of data lines 67 at regular intervals in the direction that is perpendicular to the gate lines 64. And an active layer 62 is formed with an island form in a thin film transistor region on the substrate on which gate

lines 64 and data lines 67 are formed. At this time, a thin film transistor having an active layer 62 as an active region, gate lines 64 as a gate electrode, and data lines 67 as a source electrode is formed.

And a pixel electrode 72 is formed to be connected to a drain region of an active layer 62. And a black matrix 69 is formed to be an integrated form that is superposed on one side of the pixel electrode 72, data lines 67, gate lines 64 and a thin film transistor region excluding a drain region. At this time, the black matrix 69 is used as a common electrode. Also, the black matrix 69 is formed in the lower portion of the pixel electrode 72. Here, a capacitor composed of a black matrix 69, an insulating film (not shown), and a pixel electrode 72 is used as a storage capacitor.

A method for manufacturing a LCD according to the second embodiment of the invention having such a structure will be described below.

At first, since the processes of Fig. 7a-7d are same with the first embodiment according to the invention, explanation will be omitted. The processes after that will be described below.

As illustrated in Fig. 7e, a black matrix is deposited and patterned on the fore surface of a substrate 61 including the second interlayer insulating film 68, and then connected to the common electrode. At this time, the black matrix 69 is patterned not to be remained in the upper portion of the drain region of the active layer 62.

And as illustrated in Fig. 7f, an insulating film 70 is deposited on the fore surface of a substrate 61 including a black matrix 69, and a gate insulating film 63, the first and second interlayer insulating film 65, 68 and a part of the insulating film 70 are removed to form the second contact hole so that the drain region of the active layer 62 is exposed.

Continuously, as illustrate in Fig. 7g, transparent conducting material such as ITO (Indium Tin Oxide) is deposited and patterned on the fore surface of a substrate 61 including an insulating film 70 to form a pixel electrode 72 to be connected with the active layer 62 via the second contact hole 71. Here, a black matrix 69, an insulating film and a pixel electrode 72 are superposed and form a storage capacitor. Also, the black matrix 69 is used as a common electrode of the storage capacitor.

And as illustrated in Fig. 7h, manufacturing lower substrate of a LCD is completed by depositing a protective film 73 in fore surface of the substrate 61 including the pixel electrode 72, and opening a PAD.

**[Benefits of the Invention]**

The LCD and the method for manufacturing the same according to the invention could improve an aperture rate by reducing the size of a storage capacitor inside of a pixel region since a storage capacitor is formed in the portion where a pixel electrode and a black matrix are superposed. Also, in the prior art, an active layer is contaminated and damaged by forming a photosensitive film pattern to define a lower electrode of a storage capacitor and implanting impurities. However, the present invention makes it possible to manufacture a LCD having an excellent property by forming a storage capacitor with a pixel electrode and a black matrix.

**[CLAIMS]**

[Claim 1]

Liquid crystal display device having a pixel area in a matrix form and a plurality of gate line and data line formed perpendicularly in-between the pixel area, characterized in that comprising:

an active layer formed with a source region and a drain region on each substrate of the pixel area,

a thin film transistor formed with the active layer as an active region, the gate line as a gate region and the data line as a source electrode,

a pixel electrode formed in the pixel region to be connected to the impurity region of the thin film transistor, and

a black matrix for a storage capacitor formed on a upper portion of the pixel electrode and formed in a unit to be superposed on the thin film transistor region, gate line, data line, and one side of the pixel electrode.

[Claim 2]

The device of claim 1, characterized in that the black matrix for the storage capacitor is used as a common electrode.

[Claim 3]

The device of claim 1, characterized in that the black matrix for the storage capacitor can be disposed in the lower part of the pixel electrode.

[Claim 4]

Method for fabricating a liquid crystal display having a pixel region of a matrix form, and a plurality of gate lines and data lines formed perpendicularly to each other in-between the pixel region, characterized in that comprising the steps of:

forming an active region in a certain region of a substrate and forming a gate insulating film on the active layer,

forming a gate electrode in a certain region of the upper part of the active layer and forming a source region and a drain region by injecting/implanting impure ions using the gate electrode as a mask,

forming a first interlayer insulating layer at the fore surface of the substrate comprising the active layer and forming a first contact hole to expose the source region, forming a data line to connect to the source region through the first contact hole and forming a second interlayer insulating film at the fore surface of the substrate,

forming a second contact hole to expose the drain region of the active layer and forming a pixel electrode to connect to the drain region through the second contact hole,

forming a insulating film at the fore surface of the substrate comprising the pixel electrode, and

depositing and patterning a black matrix on the insulating film to cover the thin film transistor, gate line, and data line, and one side of the pixel electrode, and connecting it by a common electrode.

[Claim 5]

The method of claim 4, characterized in that the black matrix is used as a upper electrode of the storage capacitor..

[Claim 6]

Method for fabricating a liquid crystal display device having a pixel region in a matrix form and a plurality of gate lines and data lines formed perpendicularly to each other in-between the pixel region, characterized in that comprising the steps of:

forming an active region at a certain region of a substrate and forming a gate insulating film on the active region,

forming a gate electrode at a certain region of a upper part of the active region and forming a source region and a drain region by injecting impure ions, using the gate electrode as a mask,

after forming a first interlayer insulating film at the fore surface of the substrate comprising the active layer, forming a first contact hole to expose the source region;

forming a data line to connect to the source region through the first contact hole and forming a second insulating film at the fore surface of the substrate,

forming a black matrix to cover the thin film transistor excluding the upper part of the drain region, gate line and data line, and one side of the pixel region by depositing and patterning the black matrix on the second interlayer insulating film,

forming an insulating film at the fore surface of the substrate comprising the black matrix and forming a second contact hole to expose the drain region,

forming a pixel electrode at the pixel region to connect to the drain region through the second contact hole.

[Claim 7]

The method of claim 6, characterized in that the black matrix is used as a lower electrode of the storage capacitor.

**Fig. 1**

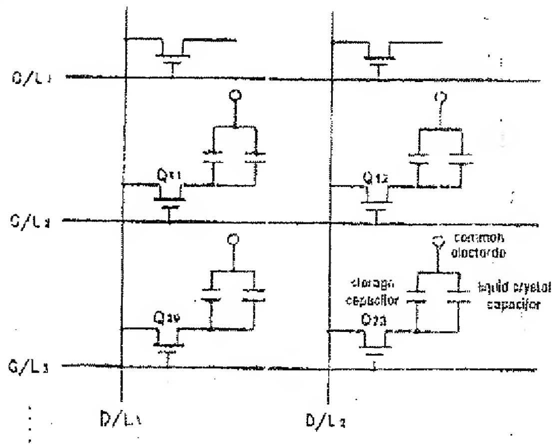


**Fig. 2**

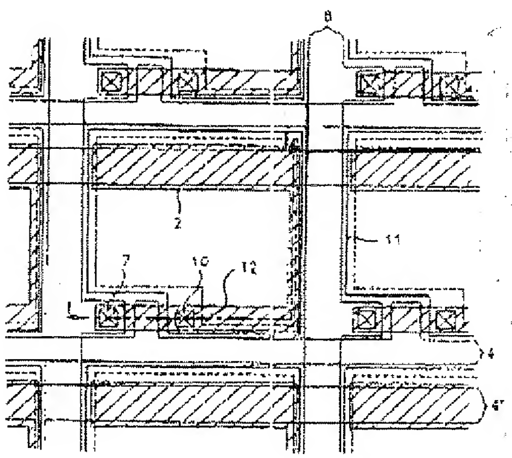


**Fig. 3a**

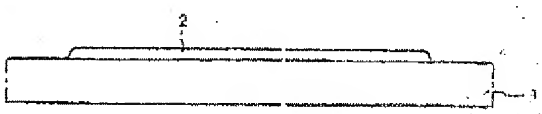


**Fig. 3b**

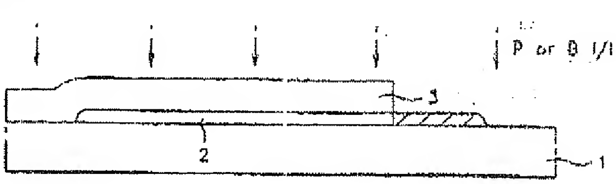


**Fig. 3c**


Fig. 3d

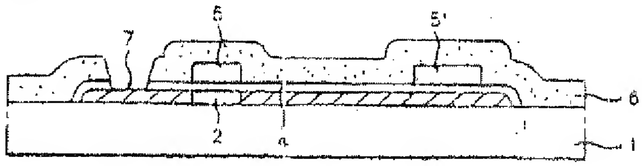


Fig. 3e

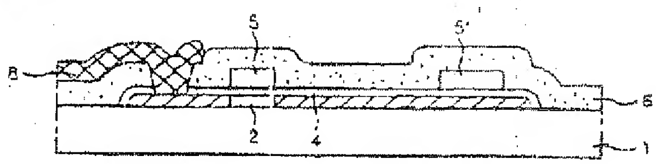


Fig. 3f

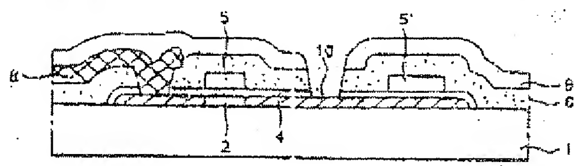


Fig. 3g

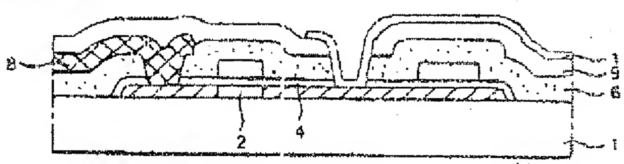

Fig. 3h

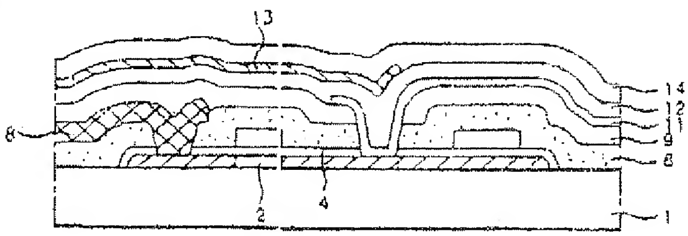


Fig. 4

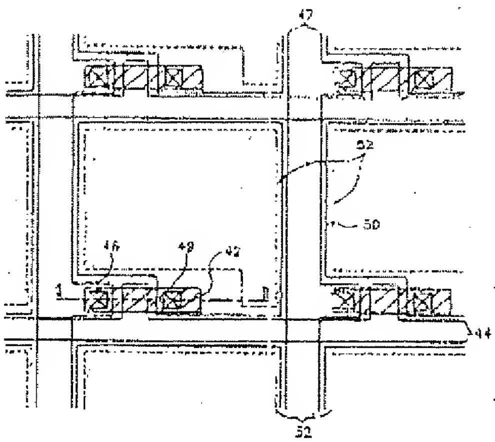


Fig. 5a

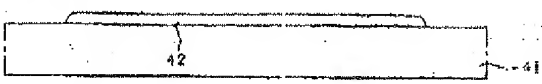


Fig. 5b

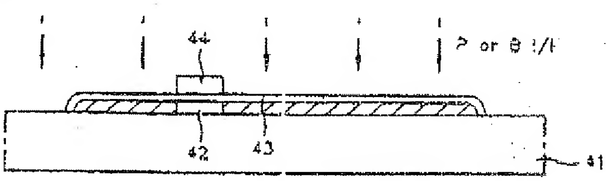

Fig. 5c

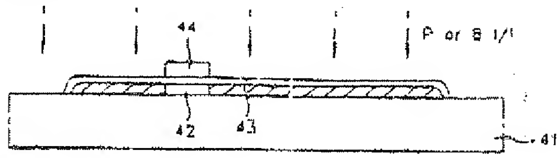


Fig. 5d

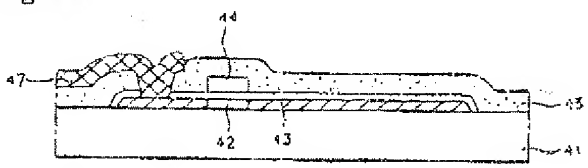


Fig. 5e

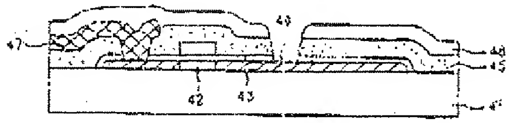


Fig. 5f

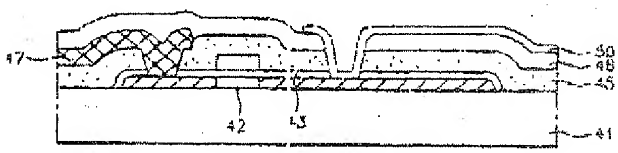


Fig. 5g

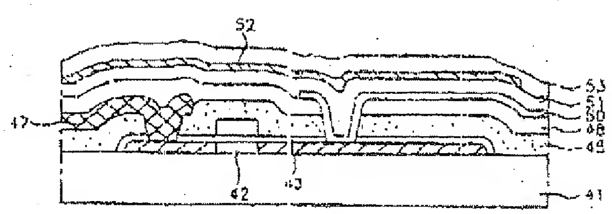

Fig. 6

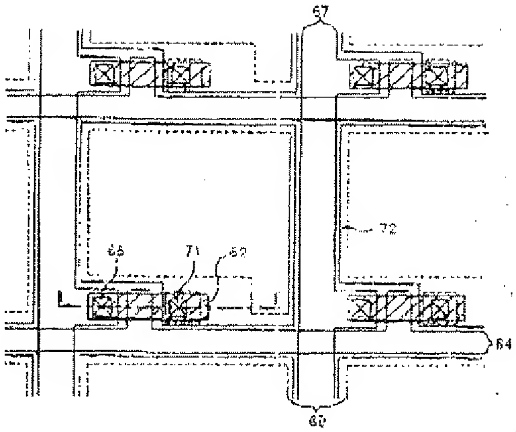


Fig. 7a

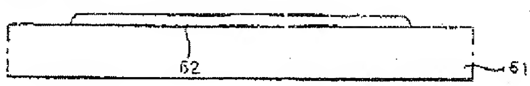


Fig. 7b

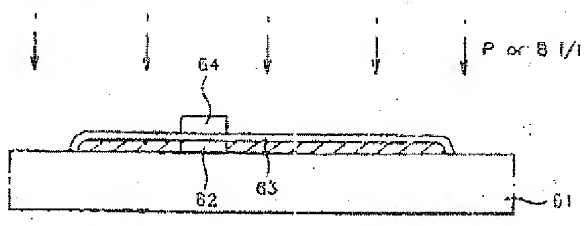


Fig. 7c

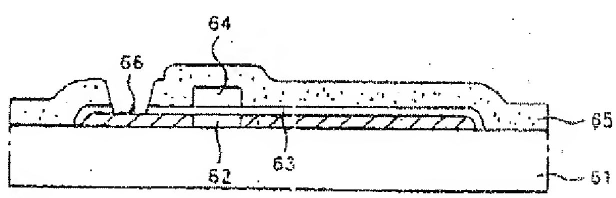

**Fig. 7d**

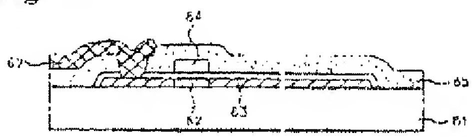


**Fig. 7e**

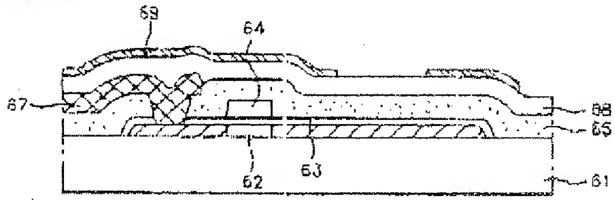


**Fig. 7f**

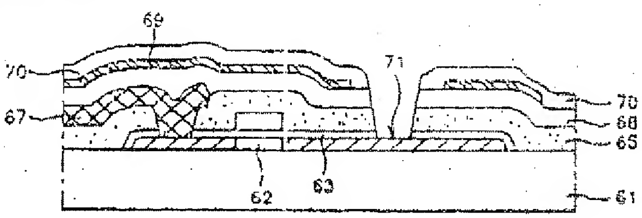

Fig. 7g

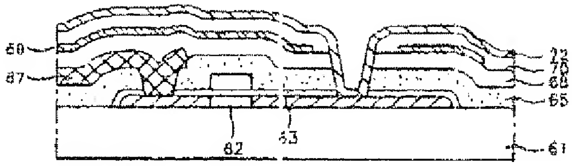


Fig. 7h

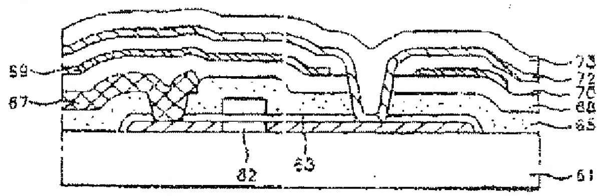

**Fig. 1**

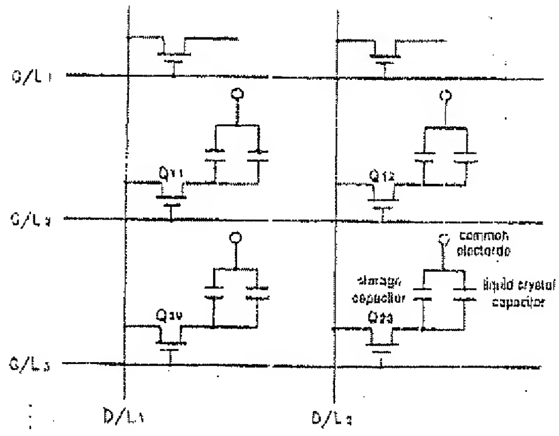


**Fig. 2**

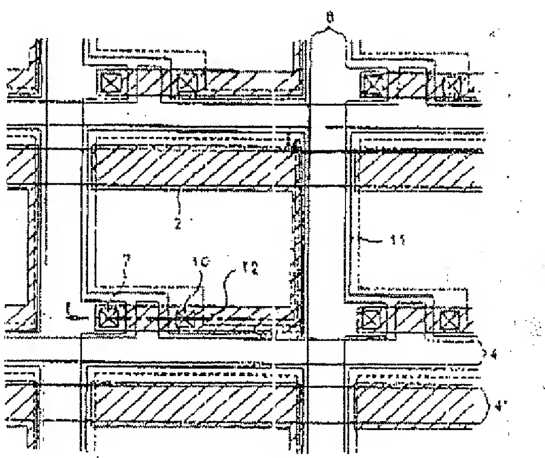

**Fig. 3a**

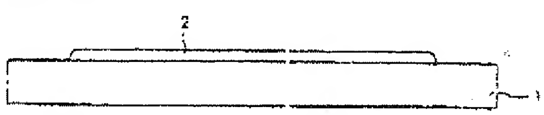

**Fig. 3b**

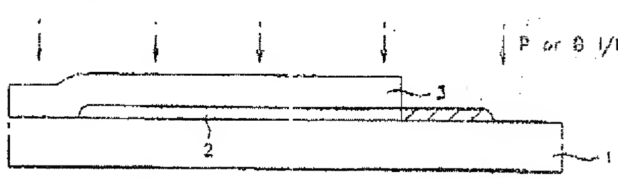


**Fig. 3c**

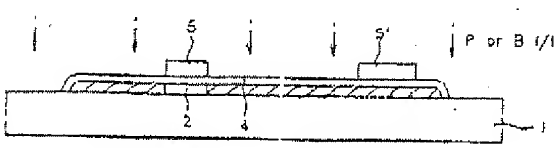


Fig. 3d

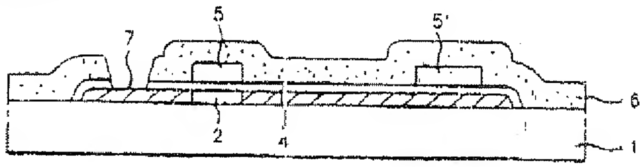


Fig. 3e

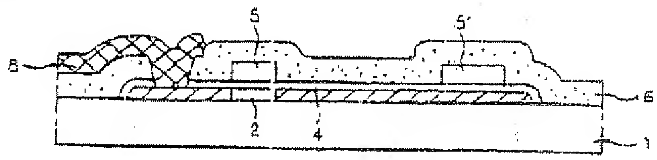


Fig. 3f

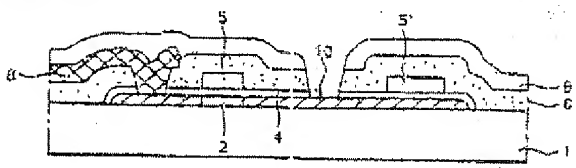


Fig. 3g

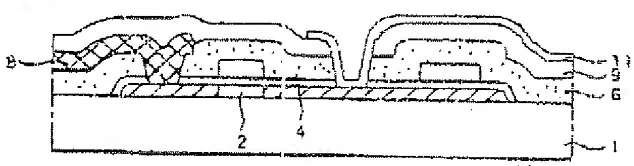

Fig. 3h

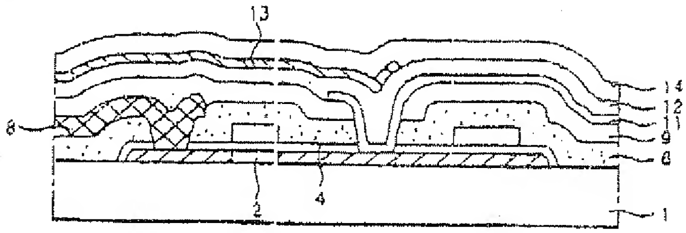


Fig. 4

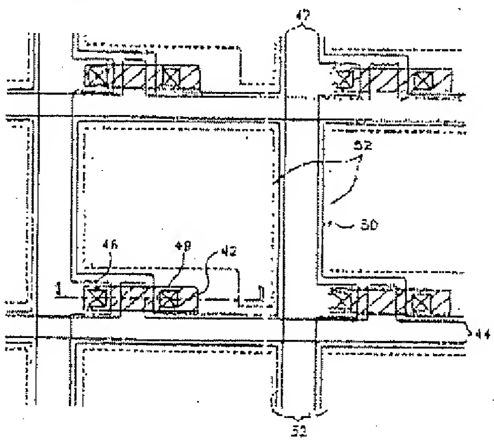


Fig. 5a

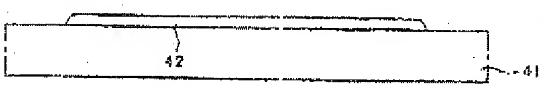


Fig. 5b

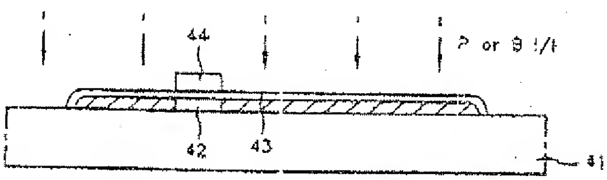

Fig. 5c

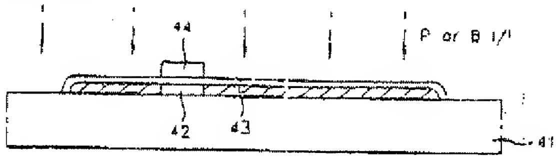


Fig. 5d

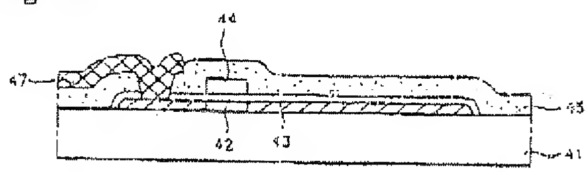


Fig. 5e

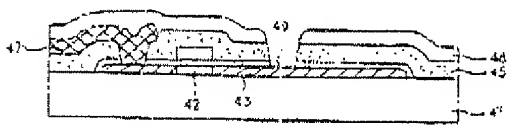


Fig. 5f

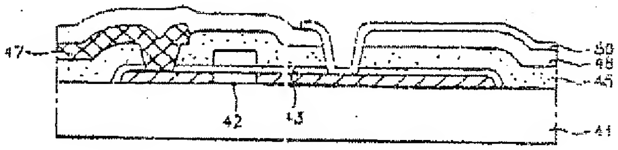


Fig. 5g

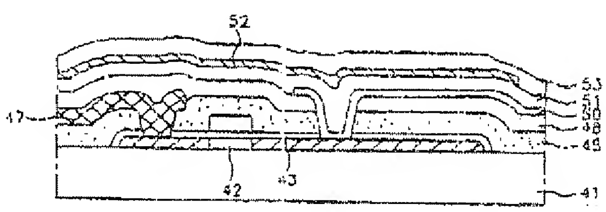

Fig. 6

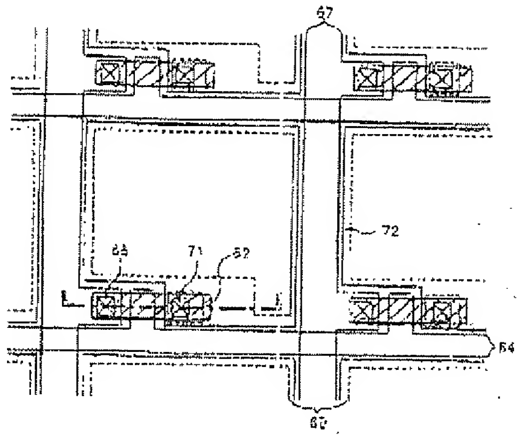


Fig. 7a

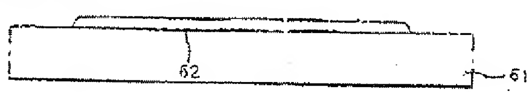


Fig. 7b

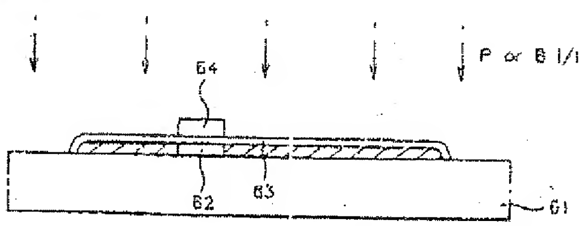


Fig. 7c

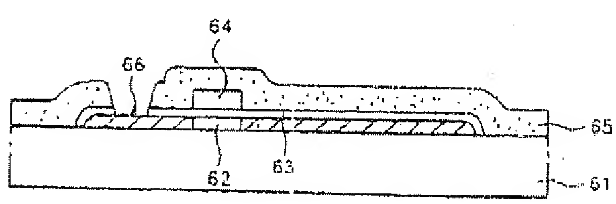

Fig. 7d

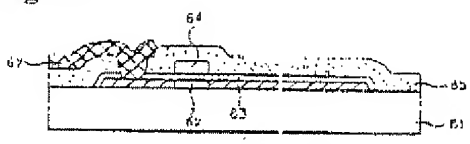


Fig. 7e

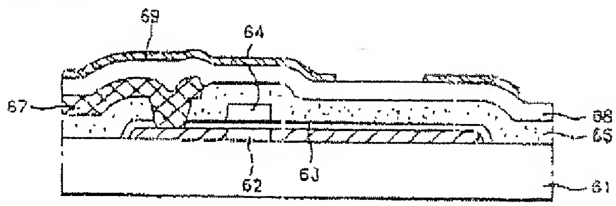


Fig. 7f

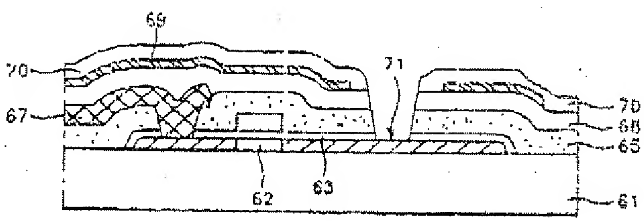

Fig. 7g

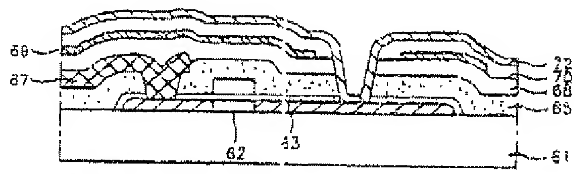


Fig. 7h